Limitations of isotopic and elemental signatures of oxygenic photosynthesis: A possible solution?

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The appearance of oxygenic photosynthetic bacteria is recognised to be one of the major processes involved in the rise of oxygen in Earth's atmosphere. This process permitted the development of more complex aerobic lifeforms. However, the timing of the appearance of oxygenic photosynthesis and that of the oxygenation of the Earth are still debated [1] and constraining the event remains a challenge.

Initially, oxygenic photosynthesis must have appeared in very localized zones [2] before having a global influence. Certain factors can influence the isotopic and elemental signatures of early oxygenic photosynthesis at the local level. These include (i) overlapping ranges of ^{13}C isotopes for oxygenic photosynthetic and heterotrophic signatures, (ii) mixing of signatures in complex, multicommunity microbial mats, and (iii) diagenetic reduction of potential redox sensitive transition metals and trace elements by heterotrophs and geochemical processes caused by the predominantly (still) anaerobic environment.

We aim to disentangle the complex isotopic and elemental signatures of photosynthetic bacterial biofilms and cells in sedimentary cherts ranging from 3.5 to 1.9 Ga. We are conducting a systematic *in situ* investigation characterizing individual microbial mats so as to understand the diffrences between fossilized anoxygenic and oxygenic photosynthetic mats. We chose to focus on individual microbial mats as they record the composition and concentration of transition metals and trace elements, as well as C and S isotopic signatures on a very fine, local scale.

We hope to be able to understand the fine scale isotopic and elemental signatures of photosyntheitc oxidation in our samples so as to contribute to the overall delineation of the record of Earth's oxyenation.

[1] Farquhar J., Zerkle A.L., & Bekker A. (2011), *Photosynthesis Research* 107, 11-36. [2] Anbar A.D., *et al* (2007), *Science* 317, 1903-1906.

A constant flux of diverse anaerobic thermophilic endospores into cold marine sediments

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Microorganisms have been repeatedly discovered in environments that do not support their metabolic activity. In a striking example of this, experiments to determine the temperature optima for sulfate reduction in permanently cold Arctic marine sediments revealed that metabolic rates were greatest in sediment that was incubated above 50°C. This response was distinct from that associated with the local cold-adapted microbial community (that catalyzed much lower rates associated with a 20°C optimum) and is explained by the germination of endospores of diverse thermophilic *Clostridiales* that lie dormant in marine sediments but can rapidly mineralize organic matter by hydrolysis, fermentation, and sulfate reduction upon induction at 50°C. Identifying and quantifying misplaced organisms such as thermophilic endospores can reveal rates and vectors of cell dispersal that shape natural microbial diversity and biogeography. In this case, endospore germination experiments that incorporated ^{35}S sulfate radiotracer were combined with a ^{210}Pb sediment age model to enable the estimation of a stable supply of thermophilic bacteria into the sediment at a rate exceeding 10^8 spores per square meter per year. Genomic comparisons indicate that the closest relatives to these and other misplaced thermophilic spores are found in warm subsurface petroleum reservoir and ocean crust ecosystems, suggesting that seabed fluid flow from deep biosphere environments may be transporting thermophiles into the cold ocean. These proposed mechanisms for the passive dispersal of microbial cells may thus connect very different provinces of the biosphere and lithosphere, and could be broadly influencing microbial community composition in the marine environment.

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